Dehydrated Food

by

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Thesis

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Topical Outline

List of Illustrations

Preface

Dehydrated foods are now coming into prominence as rivals of canned and frozen products. In my opinion, the conclusion of this present world conflict will find dehydrating an established industry with a future in the post-war markets. Not only war needs will stimulate the already increasing demand for these products, but also the rehabilitation period after the war on a world wide basis. The civilian consumer market at present is not of prime importance. However, with the proper backing the civilian consumers will come to be a large portion of the post-war market. The literature on dehydrating is still as yet confined mostly to industrial and scientific journals. My reading has convinced me of the hopeful future of this industry still in its infancy. In the following chapters I have attempted to present the case for dehydrating. This thesis is meant to be used as a source of information dealing with the various aspects of the production of dehydrated foods. It will give the reader an over-all knowledge of dehydrating -- the history, advantages, disadvantages, standards, equipment used in production, packaging, plant location, and plants in production.

THE HISTORY OF DEHYDRATING

Dehydrated foods are now coming into prominence again in much the same fashion as in the last war. Food must be shipped to our armed forces overseas, to our allies, and to the starving populations of the countries on which the Axis is practicing its plan of selective starvation. These foods save tonnage and space. They save packaging materials which are now at a premium. It is foolish to risk valuable lives in convoying water overseas. Therefore we remove the water and the result is dehydrated food. Drying of food has been a well known method for hundreds of years. Archeologists have found stores of dried grains in their excavations. The Early New England colonists learned from the Indians to dry corn, apples, peas, and other vegetables. The dried cod was a staple commodity and a source of wealth to the Massachusetts Bay colony in trade.

About one hundred years ago from England came the process of canning. One definition of canning is "the process of hermetically sealing food in airtight cans and heating. An Englishman, Saddington, and a Frenchman, Appert, received patents for this process in 1806 and 1810, respectively. The simplicity of canning and its adavantages "apparently completely overshadowed the simpler process of drying."* The canning process grew until there came about

*Prescott,S.C.-"Relation of Dehydration to Agriculture"-1919.

the great industry of today. Other methods of preservation developed; such as, freezing, salting, and pasteurization. As these other methods expanded, drying flourished only on a domestic scale and along the Pacific coast where the climate permitted this convenient method of preserving the fruit crops.

During the Civil War dehydrated soups were given to the troops to prevent scurvy. With the discovery of gold in Australia, a small plant to dehydrate vegetables was started in 1886 to supply miners and explorers. The Klondike gold rush ten years later stimulated wide-spread importation of dehydrated potatoes. Enterprising industrialists set up plants in Washington. These were unsuccessful at first. Later during the Spanish-American War the navy bought dehydrated potatoes. The dehydrated soup mixtures left over from the Boer War were stored in paraffine lined barrels by an enterprising dealer and used in the first World War fifteen years later.

During this latter period dehydrated foods were treated strictly as an emergency measure. They lacked palatability. A long restoration period was necessary because of improper preparation and lack of technical knowledge. It was not until the First World War that serious consideration of dehydrating as a domestic industry came to the foreground.

In 1919 a dinner was served to two hundred members

of the American Society of Bacteriologists. The food was all dehydrated except for the roast, the rolls, and the ice-cream. No one was the wiser and the results were pronounced delicious. It would have been possible to have made even the rolls of dehydrated potato flour and the ice-cream of dehydrated milk powder.

Germany, for long a leader in food technology, surpassed our development of dehydrating plants. Starting in 1908 with one small plant, by 1909 she had one hundred ninety-nine. In 1917, 1900 plants were producing a total quantity of dried potatoes which was equal to three times our annual crop.*

During recent years our knowledge of dehydrating has increased greatly. The best products are practically equal to the fresh ones in flavor, texture, and nutrition. Under the sponsorship of the Government Dehydrating Committee the present method is undergoing revolutionary changes in processing and packaging.

Schools have been established; such as those at Albany, California and at the Beechnut Packing Plant at Rochester, New York. A dehydrated egg school held at Kansas City, Missouri in September of 1941 was attended by leading manufacturers and cooperative leaders. This was an act unprecedented in the egg and poultry business. At the three day session, the technology and economics of the

*Prescott,S.C.-"Dehydrated Foods"-Science, 1942 (Oct. 30).

dehydrated egg industry were outlined by authorities from the government, universities, and egg dehydrating companies. A new high was set in industrial and government relations. There was an integration and sharing of knowledge and experience on all parts.

The government hopes that a permanent industry will be established which will extend to and be of great value to all our people. * This close cooperation between the the government and the dehydrating industry is indicative of the closer alliance which will result from the present conflict.

The present dehydrating program as currently outlined by the United States Department of Agriculture is such as to encourage not only individual dehydrating industries but also soundly financed, well managed canneries, properly located, with excess boiler capacity or other readily available source of heat for drying, and with vegetable preparation equipment and plant facilities which can be utilized, to participate in the program.**

The Department has annouced that it is prepared to assist processors who meet the prerequisite conditions of the program by:

a. Contracting for the purchase of dehydrated vegetables.

**Hensley, H.C.-"Dehydration of Fruits and Vegetables" 1942.
*Prescott, S.C.-"Dehydrated Foods"-Science, Oct. 30, 1942.

b. Assisting in seeking priorities for materials needed for expansion or conversion of the plants.

c. Giving technical assistance of an advisory nature on plant installations and dehydration procedures and practices. *

While Britain has been receiving shiploads of the heretofore unfamiliar dehydrated foods on the lend-lease programs, these foods are still unfamiliar to the majority of American consumers. Beans, peas, lentils, and dried fruits have found their way into most American kitchens, but as yet most American consumers would not recognize dehydrated skim milk, dehydrated vegetables, or dehydrated eggs at sight.

The Stamp Plan families, school lunch eaters, and other families dependent on public aid are ahead of the rest of the country's food eaters in this respect. For instance; from January, 1941 to January, 1942 school children consumed in school lunches four million pounds of dehydrated skim milk and one and a half million poundsof dehydrated soup mixtures. Relief family diets utilized one hundred forty million pounds of dried fruits and vegetables.**

This all took place because in 1933 the Department of Agriculture in an effort to solve the surplus problem

*Hensley, H. C.-"Dehydration of Fruits and Vegetables",1942.
**Consumers' Guide-"Squeezing the Water Out of Food" February 1, 1942.

of the farmers turned to dehydrating. To keep surplus commodities from upseting the existing farm prices the Surplus Marketing Administration and its predecessors bought up part of the surplus for distribution to low income families and for use in school lunches. More recently preference was given to the dehydrated surplus crops by placing them on the blue stamp list.

This emergency measure to do away with part of the surplus crops is no longer necessary. It served its purpose in relieving at least part of the pressure on the farming population and also on the low income families. It, also, served the even greater purpose of acting as an experiment on large scale by which the practicality of dehydrated products was proven.

Advantages and Disadvantages

Dehydrated foods in themselves have certain advantages. At present the advantages for the armed forces are in the foreground. Samuel C. Prescott outlined them:*

a. Lower cost of actual units

b. Save space in transportation

c. Guaranteed keeping quality - cold, heat, or spoilage

d. Save storage space and labor in camp

e. Wide range of vegetable foods

f. Generally improved diet

1. Roughage

2. Alkaline salts

3. Variety of combinations possible

However, even though the rapid expansion of the dehydrating industry is due in part to these war-time advantages, its peace-time advantages outweigh the former.

The dehydrating plants are located at the production centers and the raw material for dehydration is in prime condition. This immediate processing assures uniformity of quality.

Greater flavor, aroma, and the nutritive values of the foods are fully conserved. These are preserved in the water added for reconstitution. By adding only the specified amount and cooking or heating, nothing is lost by drainage.

*Prescott, S.C.-"Drying Vegetables for Army Use", 1919.

The dehydrated products have increased keeping qualities. They withstand heat and cold much more readily and even better than the fresh and canned products. Nor is there any loss by crushing, breakage, or spoilage; because when properly packaged these foods will withstand even submersion in water for a short period.

A saving is effected in the cost of transportation , overseas and transcontinental. They have less weight and bulk than an equal portion of the canned, frozen, or fresh product. Greater food value may be packed in a package of equal size.The yield of dried product of any given species varies considerably with the variety and its maturity. The yield of dried product for one hundred pounds of the fresh unprepared product varies, as there is considerable loss in sorting, trimming, and peeling.

Nichols et al give the following approximate yields in pounds of dried product for one hundred pounds of the fresh prepared product:*

*Nichols,P.F., Powers, R., Gross,C.R. and Noel,W.A. "Commercial Dehydration of Fruits and Vegetables", 1925.

Vegetable	Pounds
Green pod beans	10-13
Cabbages	8-12
Carrots	11-14
Celery	6-9
Corn	25-28
Onions	12-15
Parsnips	18-22
Peas	18-22
White potatoes	22-25
Pumpkin	7-9
Boston marrow squash	11-14
Spinach	7-11
Sweet potatoes	32-33
Tomatoes	5-8
Turnips	11-12

Comparison of Weights of Dehydrated and Canned Vegetables

(From one ton of fresh)

Vegetable	Weight prepared for canning or dehydration, pounds	Weight canned and packed, pounds	Weight dehydrated and packed, pounds
Corn.....	750	1,426	465
Peas.....	1,960	4,291	350
String beans	1,500	3,832	200
Lima beans..	800	2,300	250
Tomatoes....	1,100	1,763	125
Pumpkin.....	1,400	2,146	200
Sweet potatoes	1,450	2,259	513
Cabbage.....	1,450	2,400	215

*Source: S.C.Prescott and L.D.Sweet, Commercial Dehydration; A Factor in the Solution of the International Food Problem, Annals of American Academy of Political Science, Vol. 83 (172), 48-69, 1919.

The greatest economic factor in the use of dehydrating methods is the utilization of food stuffs which would ordinarily go to waste due to low prices at the time of production or difficulty in transportation or marketing.

From the standpoint of agriculture, the greatest advantage is in the "stabilization of crops and the conservation of materials."* The case of the potato is representative; in one year, a very large harvest, the next year, a small. Prices fluctuate and the producer suffers. By means of dehydration, the surplus of one year can be carried over to the lean year. After a period of adjustment, prices will be stabilized and a regular supply of goods will be available, other factors remaining the same.

A secondary advantage would be the conservation of food materials. It is estimated that over fifty percent of the fruits and vegetables grown in this country never reach the consumer, as a result of poor transportation facilities, irregularities in marketing, or other causes.* Prompt dehydration would eliminate the need for immediate transportation to markets.

A third factor in the agricultural advantages is the better and greater diversity of crops which can be be secured. A greater variety of vegetables and fruits can be made available to all consumers. Tropical fruits

*Prescott, S.C.-"Commercial Dehydration",1919, Annals of American Academy of Political Science.

which are rare here are plentiful at their source and sell for a mere pittance. Dehydration can make them an ordinary part of the diet.

Unfortunately, there are disadvantages connected with the use of dehydrated foods.

The first and outstanding of these is the entirely distinctive flavor of these foods. A period of soaking for reconstitution is necessary before cooking or heating for use. Directions must be read and followed carefully.

A fourth disadvantage is one which is for the most part in the hands of the manufacturer. During the interval of transit from the manufacturer to consumer, there is danger of insect infestation, mould, and "swelling" of the can. These all, however, can be prevented by correct processing methods and careful packaging.

Nutritive Values

The dehydrated vegetables produced during the first World War left a very bad impression not only because of their lack of palatibility but also because of their lack of nutritive value. Perhaps they would have been better received and accepted more widely if they had had more nutritive value. These foods rapidly lost all or nearly all of their content of vitamin C and carotene, the precursor of vitamin A. The British distributed dehydrated food supplies in 1914 which had been stored since the Boer War. These were not of the first quality and added to the downgrade course of the popularity of dehydrated foods after the war.

Much research work on the processes of dehydration and the nutritive values of dehydrated vegetables and fruits has been carried on during the past twenty five years. This work has indicated the necessity for inactivating the enzymes of vegetables and fruits by scalding, or other means, before dehydrating in order to obtain palatibility, high vitamin content, and good keeping quality.

Recently it has been found that vegetables will retain their vitamin C content well if they are stored in in the absence of air. This does not necessarily mean a vacuum. Other gases have been substituted satisfactorily. It is probable that storage in an inert atmosphere aids also in the retention of carotene. As a whole,

dehydrated fruits will retain vitamins, particularly carotene and vitamin C, much better than sun dried fruits. The use of sulphur to aid in the retention of vitamin C causes almost the complete destruction of the vitamin B 1 content (thiamin).

As a class, fruits are not important sources of thiamin. The dehydration of unsulphured fruits which are commonly preserved in this manner causes a destruction of one third to one half of the thiamin content. If the fruits were to be sulphured, the loss would vary from sixty to one hundred percent. Lye dipping, however, prior to dehydration causes no additional loss of thiamin.

In a review of the losses of thiamin from foods during processing, Harris et al* state, ""e could find no reports in which the deterioration of thiamin in rapidly dehydrated foods has been properly measured. It is likely that thiamin losses under these conditions are rather negligible."

Dehydration cuases a concentration of the carbohydrate, pectin, protein, fat, and ash constituents of fruits and vegetables. As for protein, relatively little is found in most dried fruits. The amount varies from three to five percent, depending upon the fruit in question. The legumes, however, contain much protein.

*Harris,B.S.,Proctor,B.F., Goldblith,S, and Brody,J, 1940, "Effect of Processing on the Vitamin B Content of Foods".

No other data on the availibility of the protein of fruits and vegetables were found in the literature covered.

Sun drying is destructive to the carotene of raisins, figs, and some other fruits. In the case of most fruits, dehydration causes relatively little loss of carotene, when moving sir currents are used. The custom of sulphuring fruits and vegetables before drying does not cause an increased loss of carotene, but in some experiments, aided in its retention. This was due to the sulphur dioxide which inactivated the oxidizing enzymes which are in part responsible for the loss of carotene.

Vitamin C, ascorbic acid, is retained to a considerable degree in dehydrated sulphured peaches and apricots.* In order to obtain as complete retention of Vitamin C as possible it is necessary to inactivate the oxidizing enzymes either by sulphuring or by rapid heating and then dehydration in absence of direct sunlight. Little destruction of the antiscorbutic vitamin is caused by spray drying at a temperature high enough to inactivate the oxidizing enzymes or rapid dehydration on heated drums or rolls. Fresh vegetables as a class are excellent sources of vitamin C; ascorbic acid is especially sensitive to oxidation, for this reason vegetables other than rhubarb, tomatoes, cabbages, and root crops rapidly lose vitamin C when stored at room

*Tressler, D.K.-"Nutritive Value of Dried and Dehydrated Fruits and Vegetables." 1942, March, N.Y. State Agricultural Experiment Station.

temperature or higher.*

Riboflavin is sensitive to light; therefore, sun-drying probably causes some loss, however no data was found which would indicate that the dehydrating processes cause material loss of riboflavin. The general facts are that riboflavin is remarkably resistant to heating even in the presence of air and that light is the principal hazard in processing.

*Tressler, D.K.-"Nutritive Value of Dried and Dehydrated Fruits and Vegetables", March, 1943, N.Y. State Agricultural Experiment Station.

Standards

Dehydration is not a field to be entered in any haphazard manner by anyone.* The quality of the dehydrated products made available at present will determine the post-war position of the industry. Many inconveniences will be tolerated during the emergency but after the restraint is withdrawn, dehydration will sink back into the oblivion which enveloped it after the last war. Only certain varieties and grades of fruits and vegetables have been found to be suitable for dehydration. Experimentation is still going on and no doubt still more varieties will be found to be available. Expert handling and knowledge of the dehydrating process is essential for a product of good quality.*

Just as the dehydrating process itself is important, so is the careful preparation of the raw material. These steps consist of washing, sorting, trimming, blanching, and traying. The first three steps are self evident. The purpose of the blanching by steam is to inactivate the enzymes which are believed to be responsible for undesirable changes in color, flavor, texture, and loss of vitamins during drying and subsequent storage. Traying is also an important operation. The practice of overloading trays to increase the capacity of the dehydrator

*Hensley, H.C.-"Dehydrationof Fruits and Vegetables",1942, U.S. Farm Credit Administration.

is inefficient. This retards the air flow through the raw material, resulting in longer drying time and loss of quality and yield.

The value of a control laboratory is often underestimated. Every dehydrating plant should have such a laboratory to plan and supervise every step of the preparation and dehydration; for only by careful and scientific processing can a finished product of lasting quality be obtained. The finished product should be tested for moisture content, behavior on refreshing(preliminary soaking), and cooking. Samples should be selected from not only the prepackaged, packaged, and stored product, but also from the grocer's shelf.

These tests may be scored on a plan such as this:*

Drained weight	20
Color	10
Texture	30
Flavor	30
Odor	10
Total	100

*Cruess, W.V. and Irak, E.M.-"What's Known Today about Dehydrating Vegetables"-Part V-Food Industries, May , 1942.

Deductions may be assessed for off odors, lack of palatability, or other objectionable features. Vitamin assays, however, need apparatus and methods that are beyond the capabilities of the average factory control laboratory. Advice on these assays may be secured from the Home Economics division of the Department of Agriculture.

Samuel C, Prescott in a talk at New Orleans, October of 1919, gave what he considered should be the bases for the control of dehydrated foods. These tests still are good:*

a. Raw material

b. Preliminary treatment

c. Process of drying

d. Protection against spoilage

e. Insects

f. Sanitation of factory

Earlier that same year Dean Prescott had given his own individual tests for dehydrated vegetables for Army use. The former tests could be used for testing of the product at the base of production. These tests to be presented should be applied by the producer from the consumer viewpoint.

*Prescott, S.C.-"What Should be the Basis of the Control of Dehydrated Foods?" -October 6, 1919.

a. Physical appearance.

b. Soak-back quality (good, bad, fast, slow)

c. Keeping quality (moulds, bacteria, insects)

d. Action of enzymes

e. Absorption of moisture from air

f. Cooking quality -- retention or loss of flavor

g. Effect of type of container on the character and keeping quality of the food *

The federal specification of the Agricultural Marketing Administration base their inspection on these points:**

a. Raw material

b. Preprocessing machinery and preprocessing activities

c. Dehydrating activities, including methods, temperatures, humidity, and air-flow control

d. Methods of packaging

e. Plant sanitation.

*Prescott, S.C.- "Drying Vegetables for Army Use"-1943

**Hensley, H.C.-"Dehydration of Fruits and Vegetables" 1943
U.S. Farm Credit Administration.

Equipment

There are five principal types of dehydrators. These are the cabinet, tunnel, drum, spray, and poultry unit dehydrators. Each type has its special uses and no single type is best for all purposes. The essential factor to be kept in mind in the construction of a dehydrator is that the mechanical equipment used should be such that the vegetables are kept free from contact with copper, galvanized iron, or other metals which tend to destroy flavor, color, and vitamins.

Besides the dehydrator there must be a source of heat. The sources for heat may be indirect or direct. The indirect is through a steam boiler; the direct through a gas- or oil-fired burner.

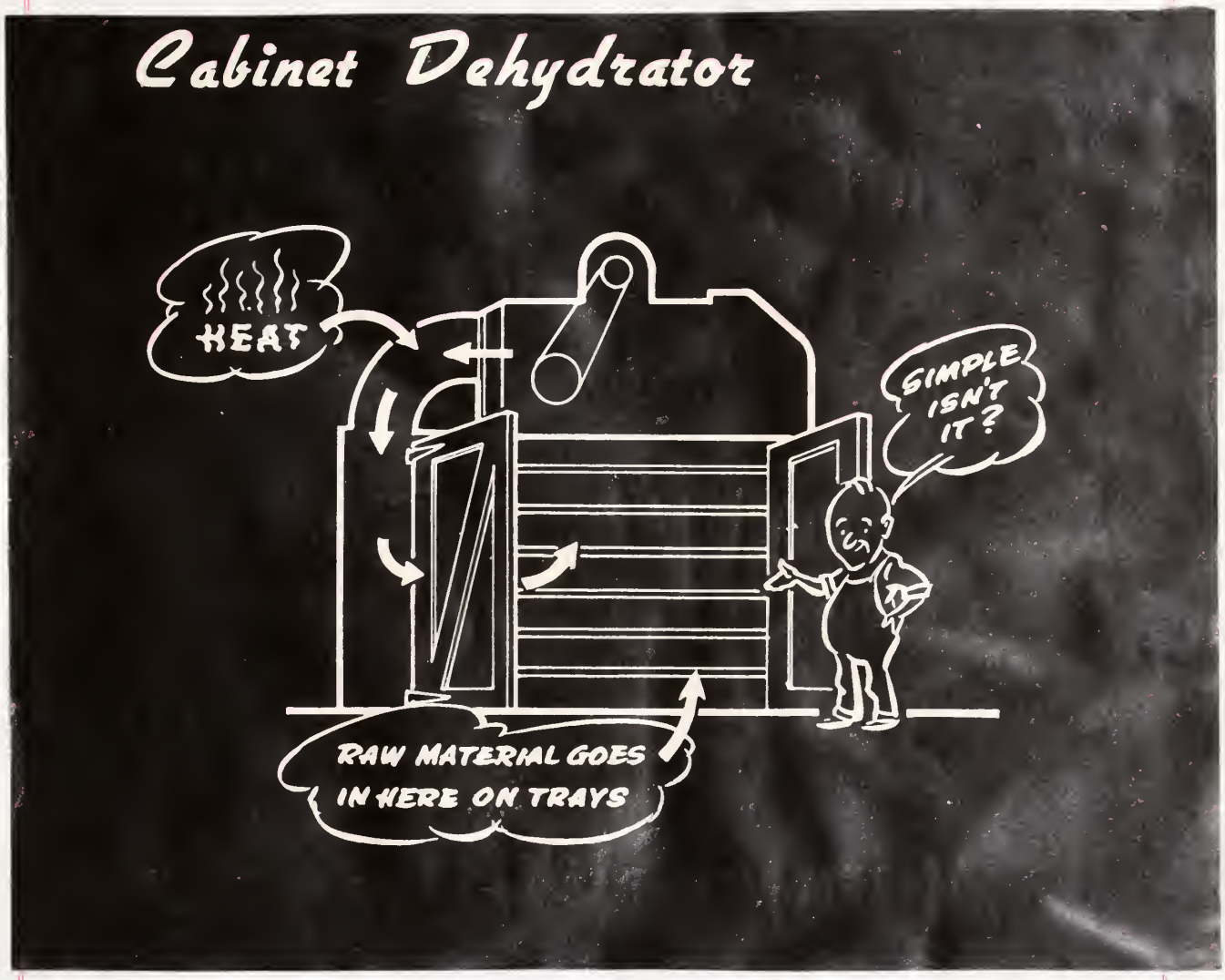
If the heat is to be supplied indirectly through a steam boiler, the boiler capacity required for dehydrating is estimated to be six to ten boiler horse power per ton of vegetables to be dehydrated in twenty four hours. The heat from the boiler may be transferred to the circulating air through steam radiator installations.

The direct heating may be supplied by either a gas- or an oil-fired burner. When natural gas or oil is burned directly in the drying air, substantially all of the heating value of the fuel is made available for dehydration. With proper safeguards, some grades of fuel may be burned directly in the circulating air without damage to the product. Natural gas when/an abundant

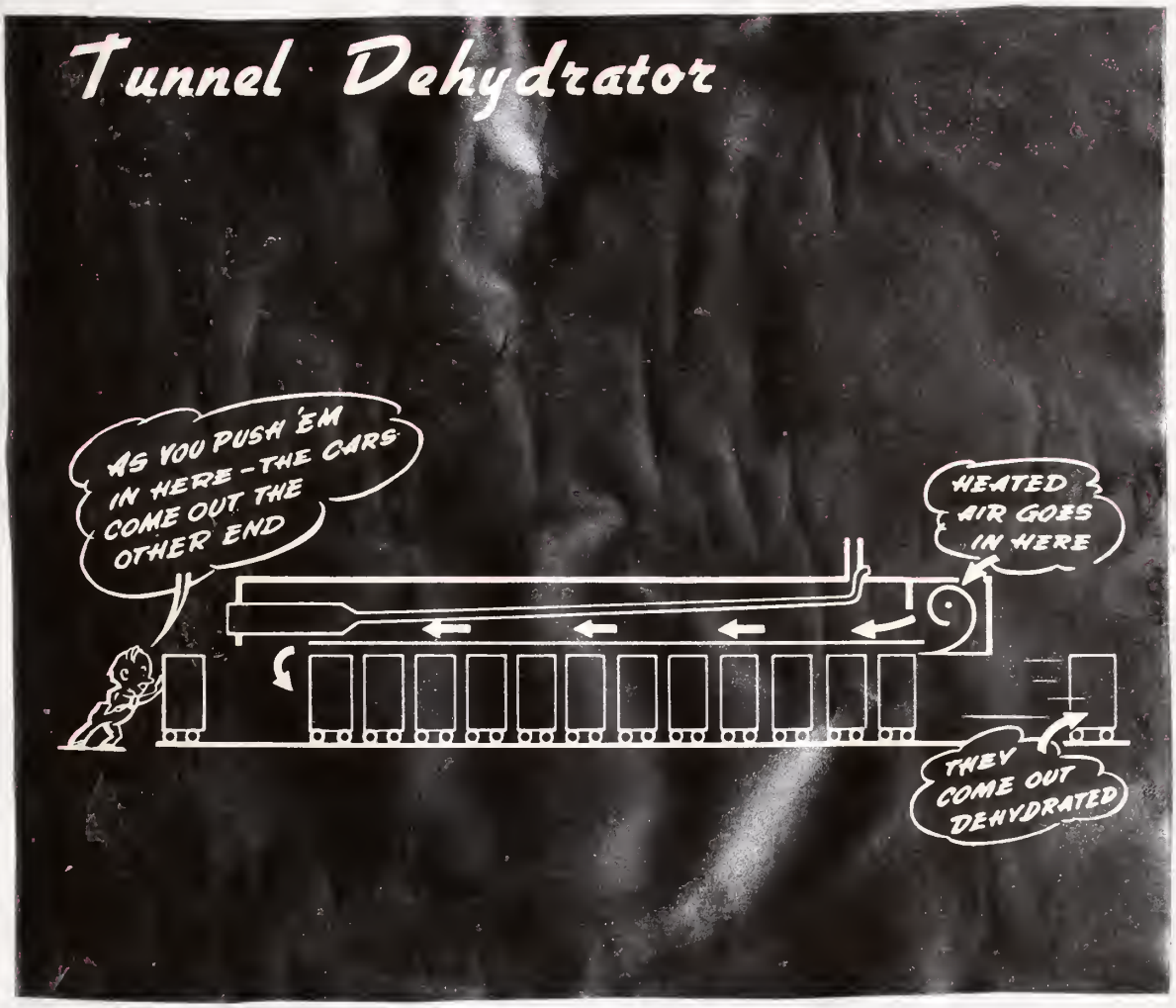
and economical fuel, may be used to heat the circulating air by direct combustion of the gas in the air system of the dehydrator.* The amount of heat which must be applied to the circulating air ranges generally between 2,000 and 5,000 B.T.U. per pound of water evaporated.

The cabinet type of dehydrator is the least expensive and/the simplest to construct. Its use is more satisfactory where the labor supply, legal restrictions, or other conditions favor discontinuous operation. It is particularly suited for use in small scale production, pilot plant operations, and where connections can be made with existing steam lines. This type consists of a compartment into which trays of the raw material are placed and into which heated air currents are introduced. It may be used for most vegetables and some fruits. The necessary drying time depends upon the commodity. For many products it is possible to make two runs for each 12-14 hour day. Its primary advantage is its low cost of construction which may be less than one thousand dollars exclusive of the preparation material and boiler or other source of heat.

*Hensley,H.C.-"Dehydration of Fruits and Vegetables"-1945 U.S. Farm Credit Administration.



Wensley, Harry C. - "Dehydration of Fruits and Vegetables by Farmers' Cooperative Associations".- U.S. Farm Credit Administration, August, 1940.



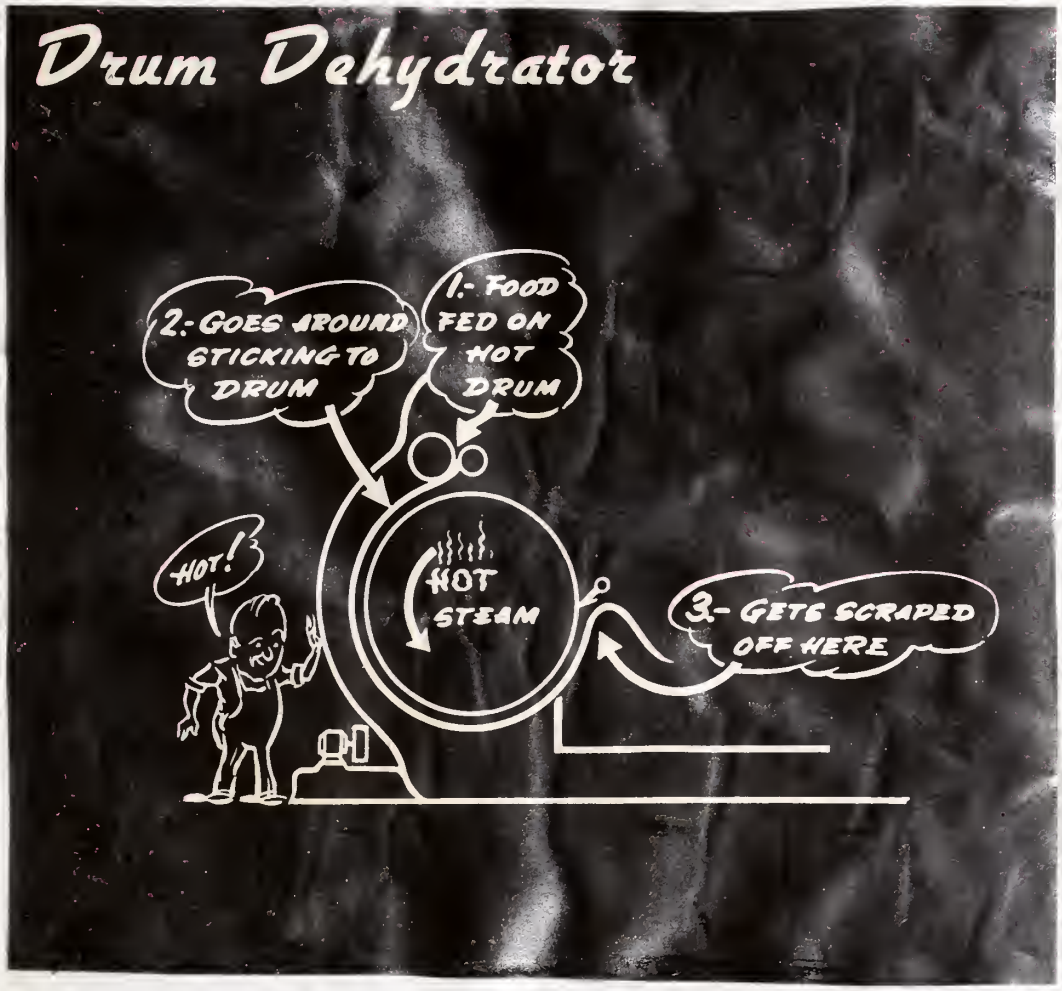
Bensley, Garry J. - Dehydration of Fruits and Vegetables by Farmers' Cooperative Associations." Circular, 1948, U.S. Farm Credit Administration.

The principle of the tunnel dehydrator is similar to that of the cabinet dehydrator. The differing factor is that in the tunnel dehydrator the raw material is moved through the tunnel on trucks instead of remaining stationary. As in the cabinet type, the heat is introduced through fans. It, too, may be used for most vegetables and fruits. The advantage of this method is its economy due to the large volume which may be dehydrated at one time. The Washington Packers, Inc. have a dehydrator of this type which is semiportable. It is built in sections of insulated sheet steel bolted to angle bars for convenience in moving.

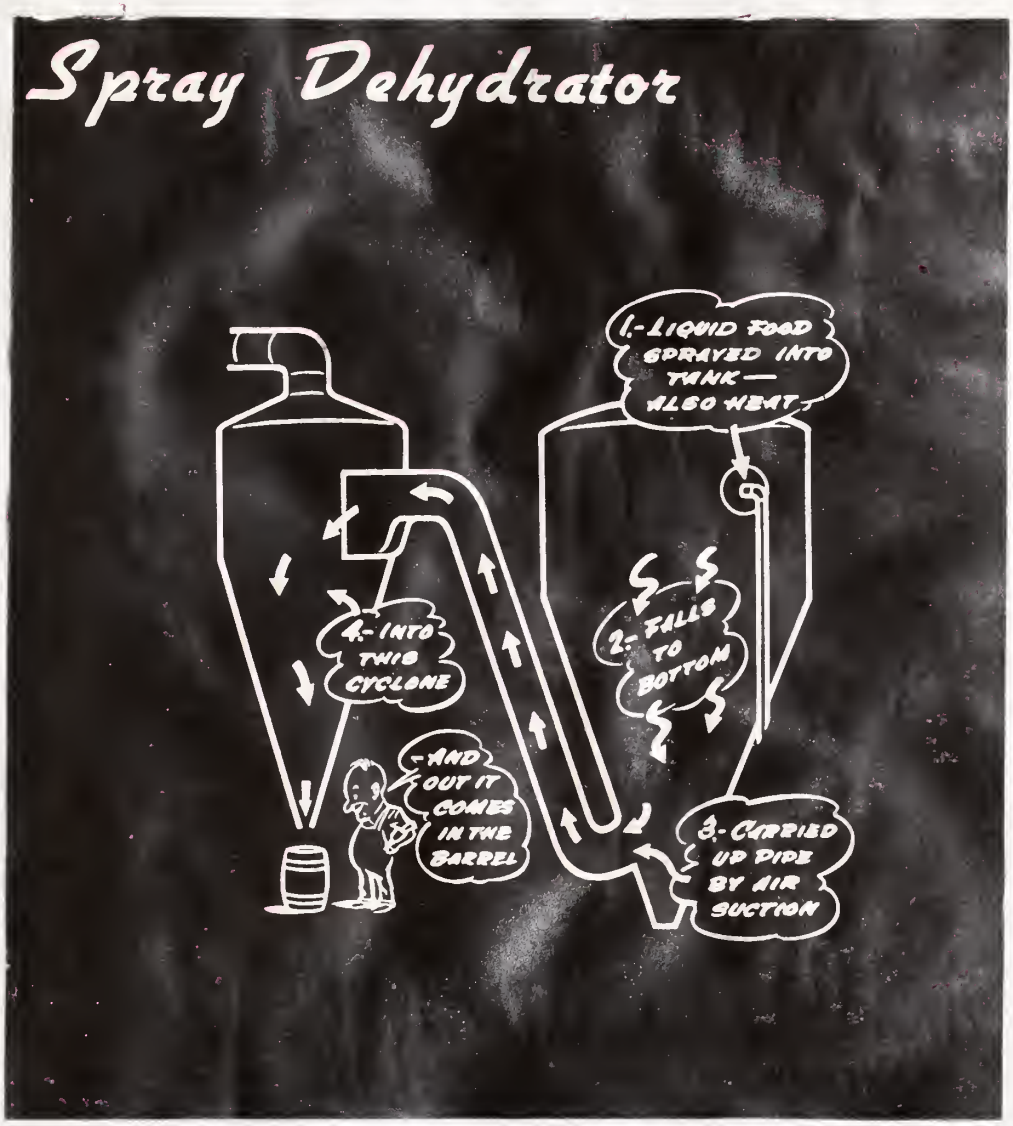
The thirty five ton center exhaust twin tunnel dehydrator with vestibules and recirculation, described in the United States Department of Agriculture Plans, No. E-69, provides a satisfactory unit for commercial operations. Additional units may be added with additional experience as conditions justify. Equipment manufacturers are prepared to suggest desirable plant layouts and give valuable counsel on preparation equipment capacity.*

In the drum dehydrator, the raw material is spread in a semi-liquid form on the surface of the revolving steam-heated drum. The dehydrated product is scraped off in a few seconds later in the form of a thin sheet

*Hensley,H.C.- "Dehydration of Fruits and Vegetables",1943 U.S. Farm Credit Administration.



Wensley, Henry C. - "Dehydrating Fruits and Vegetables by Farmers' Co-operative Associations." August, 1947, U.S. Farm Credit Administration.



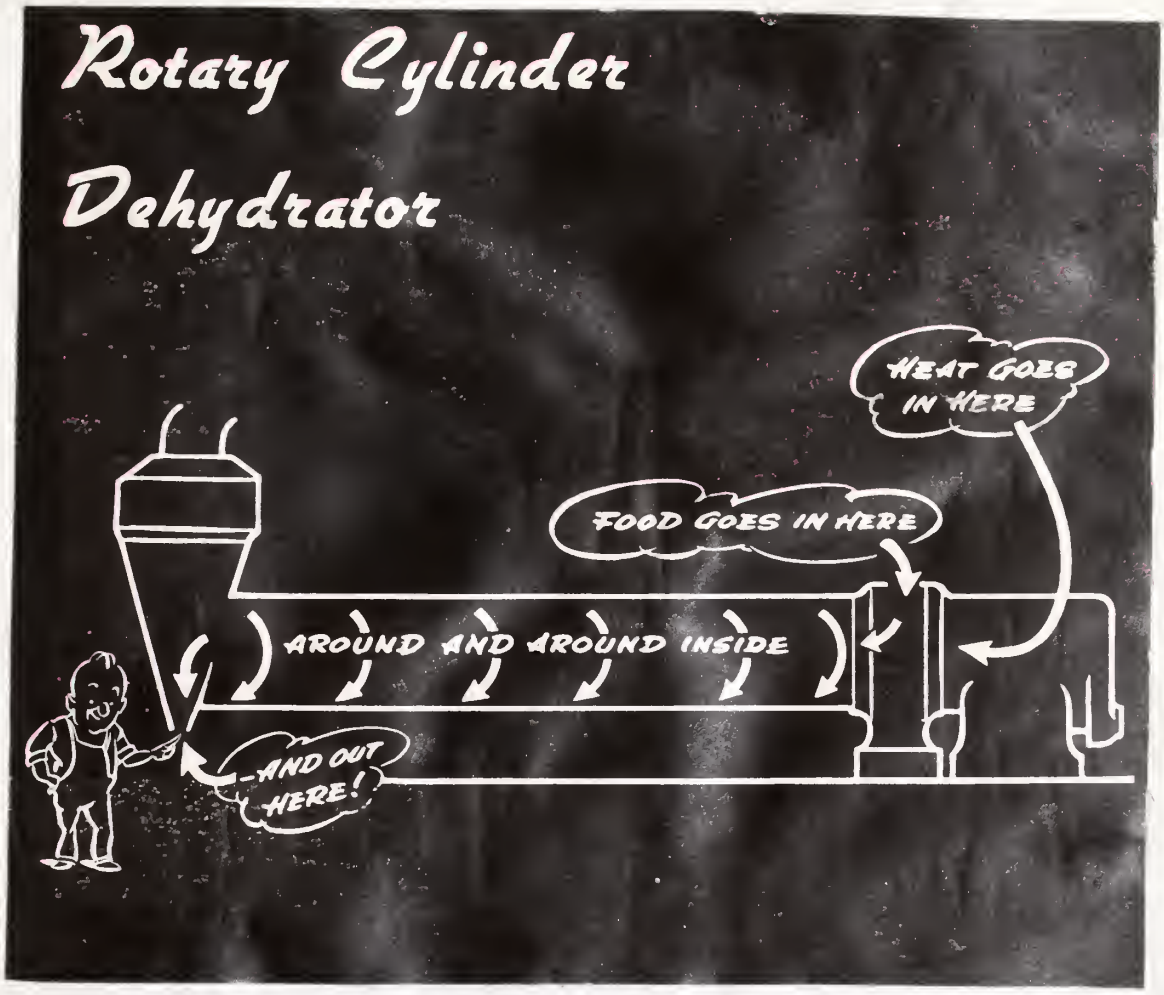
Hensley, Danny C.-"Dehydration of Fruits and Vegetables by Farmers' Cooperative Associations." August, 1948, U.S. Farm Credit Administration.

which is easily converted to powder. This method is suitable for products which can first be reduced to a semi-liquid form and do not require the retention of the approximate shape and texture of the original raw commodity.-- soups, applesauce, cranberries, pectin, etc. At this time this type is not in wide use because of the need for critical materials for its construction. One advantage of this drum dehydrator is that while it used generally to dehydrate vegetable and fruit products, it may be used in the off seasons to dehydrate soups.

For the spray dehydrator, the food in a liquid form is homogenized and forced under pressure and in a light spray into the drying chamber. Heat is introduced simultaneously and the resulting whirlwind action dries the product almost instantaneously.* The powder falls to the bottom of the chamber and is carried by the hot air currents through the secondary drying devices. Dairy cooperatives, primarily, use this method to produce milk powder. It is particularly adapted to milk, eggs, and possibly fruit and vegetable juices.

In the rotary cylinder dehydrator the hot air and raw materials are introduced into a rotating cylinder. The rotating movement keeps the product flowing through until it is ejected in its dehydrated form at the other

*Hensley, H.C.-"Dehydration of Fruits and Vegetables," 1942 U. S. Farm Credit Administration.



Wolsley, Harry C.---"Dehydration of Fruits and Vegetables by Farmers' Cooperative Associations." August, 1943, U.S. Farm Credit Administration.

end. While this method is suited to the mass production of animal feeds from by-product plants, it is not well adapted to the production of dehydrated fruits and vegetables for human consumption. Its advantage lies in the relatively large volume which can be produced at low operating costs. Its disadvantages include the lack of humidity control, probable loss of vitamins, and the difficulty in maintaining the quality of the finished product.

Storage

It is customary to store the dried fruits and vegetables in bins or "sweat boxes" to permit equalization of the moisture before packing.* Dehydrated vegetables and fruits should be dried to a very low moisture content and there should be no insufficiently dried pieces; these should be sorted out and redried.

In the storage of these products insect damage presents a very serious hazard. As the fruits and vegetables are free of living insects and insect eggs after dehydration, they should be packaged immediately. If it should prove necessary to store the dried products for any period, tight fumigable rooms should be used.

Such rooms can be constructed on the floor inside the factory building; using tongue-and-groove construction, icehouse doors, and lining or painting the walls, ceiling, and floors to render them gas tight. Each variety of vegetable or fruit may be stored in separate bins or sweat boxes. These rooms should be thoroughly fumigated twice a month. The storage space should be kept as dry as possible, and if the stored products should take on additional moisture, they should be redried until crisp before packaging.

The dried vegetables and fruits make a setting attractive to insects. The loss due to insect infestation has been great where inadequate storage space has been

*Cruess, W.V. and Irak, E.M. - "What's Known Today about Dehydrating Vegetables", May, 1942 Food Industries.

used. These insects have the most common tests in attacks on dried products.--the Indian meal moth, Plodia interpunctella L.; the dried fruit beetle, Carpophilus, hemipterus L.; the saw-toothed grain beetle, Silvanus surinamensis L.; and the fig moth, Ephestia Cantella Walk. These insects lay their eggs which hatch and soon cover the dried products with excreta and webbing, making a disgusting mass. The most practical method of destroying these pests is by fumigating with a gas or vapor poisonous to them.*

Commercial packing establishments favor the use of methyl bromide. This is provided in liquified form in steel cylinders with servicemen to instruct in their use and application. This instruction is highly useful because the fumigant is highly toxic to humans and must be handled intelligently. It serves its purpose well, however, because it is extremely destructive to insect life, non-explosive, and leaves no taste or objectionable residue, in or on the treated products. It is piped into the storage rooms and is allowed to remain overnight or longer.

Chloropicrin has been used, but is not very practical because it is the well known tear gas. It is very potent and effective but is also very irritating to

*Cruess, W.V. and Mrak, E.M.--"What's Known Today about Dehydrating Vegetables", May, 1942, Food Industries.

the eyes, nose, and throat. It is advised for use in the fumigation of outdoor storage boxes on farms. Carbon disulphide should never be used as a fumigant because of its high degree of explosiveness and inflammability. Hydrocyanic acid gas(prussic acid) leaves a poisonous residue on the product and is extremely dangerous when handled by inexperienced workmen. Ethylene dichloride and carbon tetrachloride are common, inexpensive liquids for use in factories; but are not as effective as methyl bromide.

The most advisable way to fumigate goods after packaging is by the vacuum process. The cartons are placed in a large steel cylinder; the fumigant is allowed to enter under the vacuum and to penetrate the packages. Details of the equipment and procedure may be had from the Department of Agriculture.

Insects will breed in great numbers in the piles of fruit wastes and discarded vegetable trimmings. The premises should be kept free of such refuse. All doors and windows in the packaging room should be screened to exclude insects as far as possible. In fact, the most desirable situation is a tightly constructed room in which the packaging materials are stored which may be fumigated regularly. The insect eggs and other insect forms on dried vegetables and fruits can be destroyed by exposing the dehydrated product to a heat of 140

to 150 degrees F. for at least an hour.

Insects will not develop at freezing temperatures. Thus so far as insect infestation is concerned, it is possible to store the packaged product at 32-35 degrees F. indefinitely. For protection against absorption of moisture and cold-storage odors, sealed boxes or cans should be used. Cold storage also retards undesirable changes in color and flavor greatly.

Molding will occur only when the moisture content of the dehydrated product is excessive. This was one of the causes for the undesirability of the dehydrated foods of the First World War. At that time the moisture content allowed was as high as ten percent. The best protection against mold is to reduce the moisture content to below five percent and to seal hermetically.

Dehydrated vegetables and fruits slowly deteriorate through oxidative and other changes as well as due to attacks by insects. These changes occur much more rapidly in non-blanched vegetables and fruits because the enzymes are still active. Blanching at 180-212 degrees F. before dehydration will destroy the enzymes and greatly prolong the keeping quality of the products.

Even the blanched vegetables and fruits, however, will slowly deteriorate in flavor, odor, and color. These changes can be retarded by packaging the dehydrated products in vacuum sealed containers or by storage

under refrigeration. Some vegetables kept much better than others. "Dehydrated potatoes, carrots, and string beans" were "stored at room temperature in friction -top cans for three years. The potatoes and carrots were very satisfactory after soaking and cooking, but the beans had a noticeable hay flavor but were of satisfactory texture and color."*

*Cruess, W.V. and Irvk, W.H.-"What's Knorm about Dehydrating Vegetables Today." May, 1942, Food Industries.

Packaging

Packaging materials for dehydrated foods should be selected carefully by the manufacturer. The quality of the finished product as it reaches the final consumer is dependent upon the materials used in packaging as fully as it is on the quality of the raw materials used in preparing the product. The careless manufacturer will allow all his efforts to go to waste in selecting the wrong kind of material for his packages. The package is particularly important because of the moisture content of the finished product. The package should act as a barrier between the dehydrated product and moisture on the outside.

During the last war in 1918, eight to ten percent moisture content was considered acceptable. Today that is considered very high. This caused many of the difficulties of the last war -- palatability of the food and its appearance. This caused prejudice among the soldiers and the few consumers who did brave the unknown and try this little known form of preserved food. Still even then after the war, A. Louise Blandrea was able to serve two meals with properly dehydrated food at one of the meals from soup todessert and not have any of her guests suspect which meal was prepared from the fresh vegetables and meat and which from the dehydrated products. Improper packaging and a high moisture content, added to by storage in the packages, caused the growth

and development of enzymes which ruined the appearance and palatability of the food when reconstituted and cooked. Even when the moisture content is only slightly above five percent, a commonly accepted figure, it is doubtful whether there will not be adverse affection of the flavor, color, and vitamin retention of the stored food. A change of one percent in moisture content is significant in its effect on the taste and vitamin C retention.

The United States Army specifications at present are for not over five percent moisture content. The palatability and vitamin content are preserved longer if a reduction in moisture content is effected to lower levels than those now specified and commercially obtained.

Since the sales ability of a product depends so much on eye appeal, the final package for the dehydrated product should be attractive in appearance as well as being as nearly insect-proof and moisture-proof as possible.

Most dehydrated fruits are packed in paper cartons lined with some moisture-resistant material such as waxed paper, vegetable parchment, cellulose film (Cellophane or Pliofilm). The cartons are then wrapped with a tightly fitting lithographed paper and often with a waxed wrapper, cellulose film, or aluminum foil wrapping over the paper.* The cartons are usually filled,

*Cruess, W.V. and Mrak, E.M. "What's Known Today about Dehydrating Vegetables", May 1945, Food Industries.

sealed, and wrapped by machine. Although oliofilm inner linings can be made moisture-proof, they are not insect-proof. The larvae can enter by openings not visible to the naked eye. Adult beetles can easily eat their way into a carton. Since dehydrated vegetables, because of their higher drying ratios, must bring a higher price than dehydrated fruits, it is justifyable to use the higher priced but insect-proof packages. However, greater food value is packed in the equal size package.

The ideal container for dehydrated vegetables is the key-top can such as that used for coffee. These cans should be reenforced so as not to collapse under vacuum; or at least filled tightly so that the product itself will support the walls. When the cans are sealed under a high vacuum, the vacuum will protect the product against the oxidative changes and will kill insect life or prevent its development. Powdered vegetables should be packed only in tin or glass containers; these should preferably be airtight ones to prevent not only insect infestation but also absorption of moisture with consequent cooking.* These powders are also highly susceptible to oxidative changes and should be vacuum-sealed.

Glass jars can be made moisture- and insect-proof and can also be vacuum sealed. They are highly desirable because of the visibility of the product and the attrac-

*Cruess, W.V. and Mrak, E.M. "What's Known Today about Dehydrating Vegetables" May, 1944, Food Industries.

tion of the container. Most jars can be reclosed. Another advantage is their later use as drinking glasses by the consumer. The disadvantages to be found in connection with the glass containers are the added weight and fragility.

Dehydrated fruits and vegetables can also be compressed into dense bricks or cylinders (sausages) which may be wrapped in paper with an outer aluminum-foil wrapper or in transparent cellulose. The bricks may also be packed in cartons or cans. If compressed to a high density, the bricks are automatically fairly resistant to insect attack.

The ideal package for dehydrated fruits and vegetables should be impervious to water vapor, oxygen, carbon dioxide, and nitrogen. It should exclude all light and keep out insects.

Plant

Since vegetables and fruits for dehydration should be processed fresh, it is desirable to locate the plant in or near an important vegetable or fruit producing section. The available supply of raw materials should be of the proper varieties. Not all varieties of a given vegetable or fruit are well adapted to dehydration, some being better suited to the process than others. The plant should also be convenient to a dependable source of labor with access to adequate transportation facilities.* In general, the standards for plant location are comparable to those used in locating canneries.

In the following figures are shown the major vegetable producing areas. The last figure shows the location of thirty-seven cooperative canneries. Many of these thirty-seven are favorably located for vegetable dehydration.

To spread the fixed charges, a long growing season is to be preferred; however, if the cost of production of the vegetable or fruit is low, the disadvantage of a short growing season can be offset by the lower cost of the raw material. The tendency is to dehydrate a series of successive vegetables or fruits which can be obtained fresh from the farms or orchards or which can be stored, such as potatoes and onions; and thus obtain

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*Hensley, H.C.-"Dehydration of Fruits and Vegetables", U.S. Farm Credit Administration.

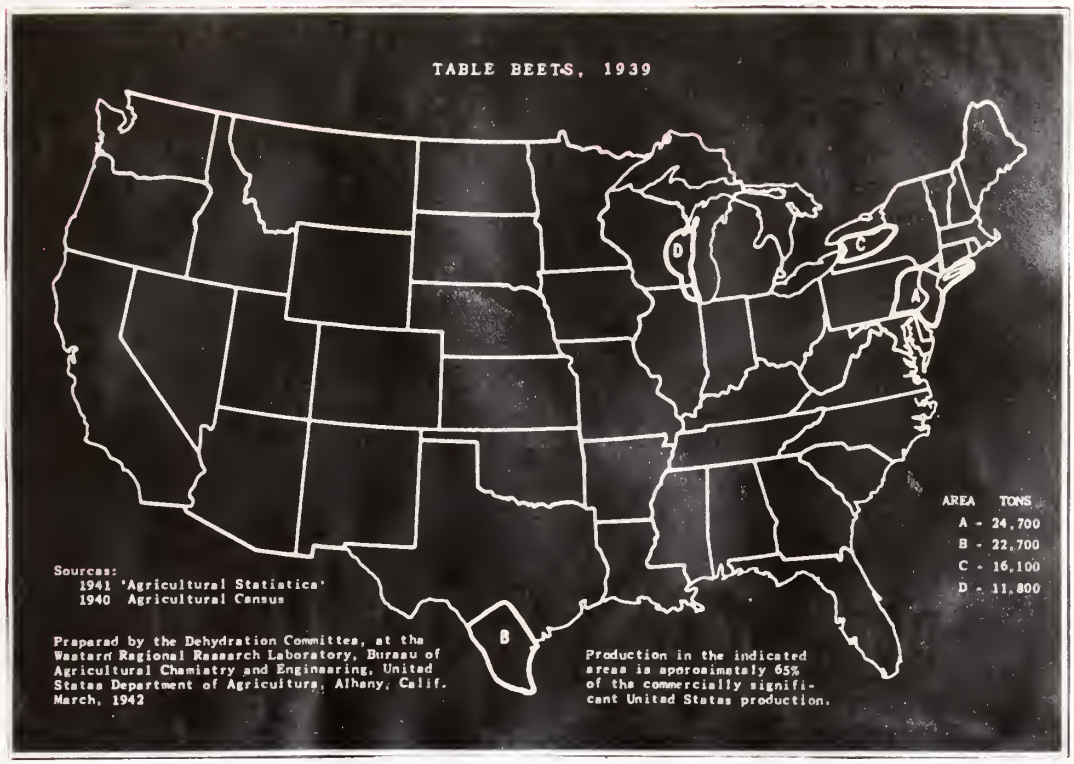
an operating period of from six to nine months. The optimum capacity for a plant for vegetable dehydration has not as yet been determined.* However, for commercial purposes the dehydration equipment should have the capacity to keep the preparation line going continuously during the workday. Most vegetables require a preparation line consisting of a grader, washer, peeler, trim line, slicer, or subdivider, blancher, and sometimes a cooker. The whole object of the setup is to keep the preparation line as well as the dehydrator working at full capacity at all times.

*Jensley, H.C.-"Dehydration of Fruits and Vegetables.",1945 U.S. Farm Credit Administration.

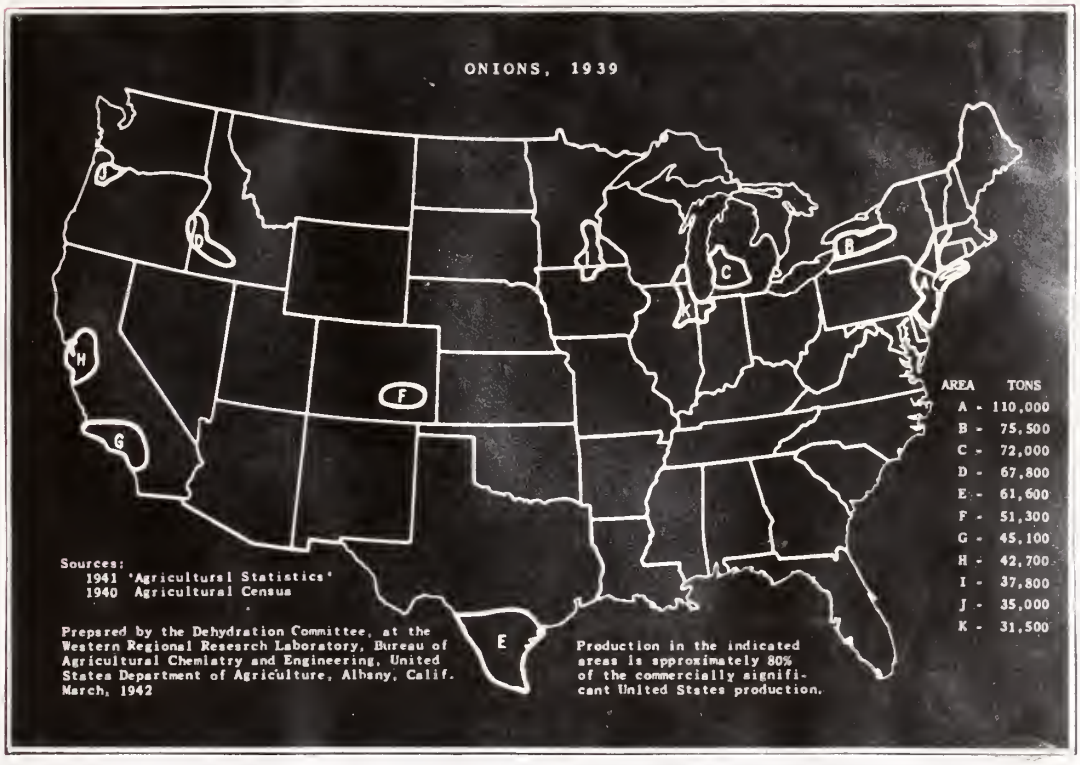
Hensley, Harry C. "Dehydration of Fruits and Vegetables by Farmers' Cooperative Associations." August, 1942, U.S. Farm Credit Administration.

Hensley, Harry C. -"Dehydration of Fruits and Vegetables by Farmers' Cooperative Associations." August, 1942, U.S. Farm Credit Administration.

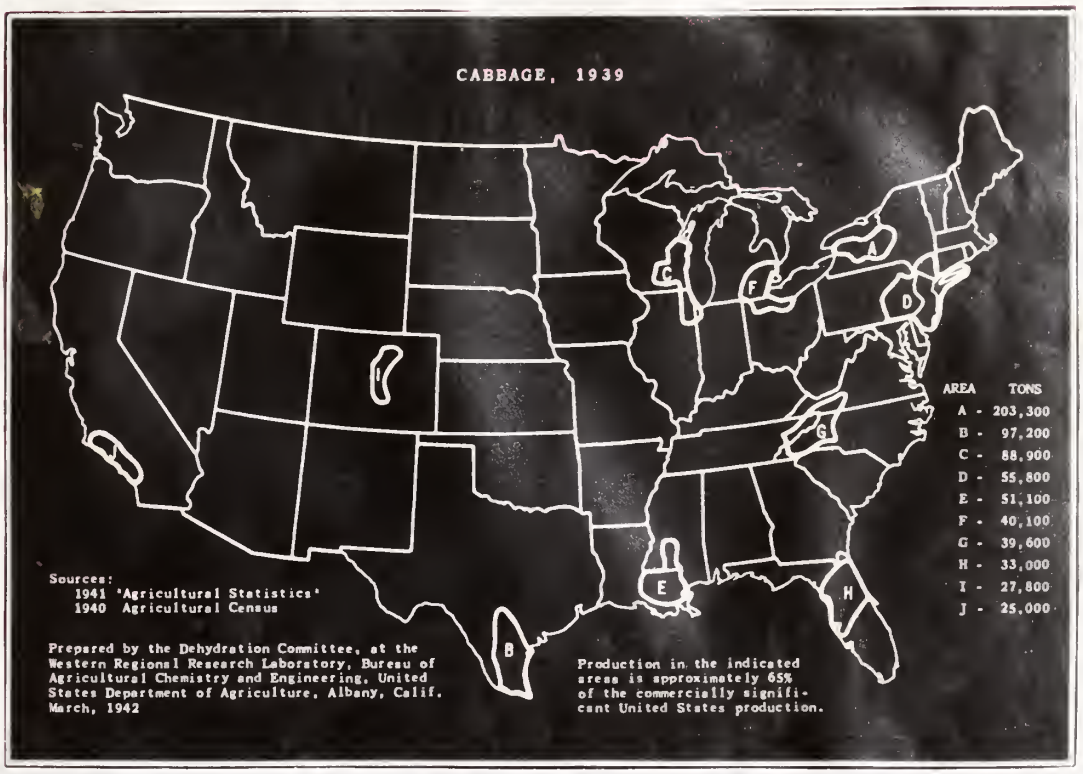
Hansley, Harry C.--"Dehydration of Fruits and Vegetables by Farmers' Cooperative Associations," August, 1942. U.S. Farm Credit Administration.



Tousley, [illegible].--"Dehydration of Fruits and Vegetables by Farmers' Cooperative Associations". August, 1942, U.S. Farm Credit Administration.



[illegible]ley, [illegible] Y. - "[illegible]tion of fruits and Vegetables by [illegible]", August, 1940.
U. S. [illegible] Credit Administration.



Dewsley, H. Kerr D.--"Dehydration of Fruits and Vegetables by Farmers' Cooperative Associations." August, 1941. U. S. Farm Credit Administration.

Thirty-Seven Cooperative Canneries.

Donsley, Mary J.--"Dehydration of Fruits and Vegetables by Farmers' Cooperative Associations". August, 1945. U.S. Farm Credit Administration.

Some Plants in Production

Although many failures, both business and technical, have been the result in past attempts to set up vegetable and fruit dehydrating plants; in 1938 the Dry-Pack Corporation tried. One of the older methods of dehydration is the D'andrea process which was developed by A. Louise D'andrea and Dr. George A. Sykes. This entire process and patent was taken over by the Dry-Pack Corporation. The latest knowledge of engineering and food technology were applied and a pilot plant was built at Sodus, New York.

"A pilot-plant operation, of which there are entirely too few in the food industry, is for the purpose of determining costs and engineering data and producing a sufficient quantity of finished goods to test the market reaction. Properly conducted, a pilot plant has for its basic concept the idea of keeping mistakes small so that profits may be large."* The plant at Sodus not only produced acceptable dehydrated vegetables butalso proved the point that dehydrated foods can undersell canned and frozen foods and still yield a reasonable profit. The company's experience in 1939 and 1940 was the basis for a large scale plant located in San Jose, California in 1941, and another at Lyons, New York, 1941. The pilot plant at Sodus was abandoned, but the firm,

*Burton,L.V.-"Dehydration Locks Up"-September, 1941. Food Industries.

Skinner and Udy, makers of "Minute Man" dehydrated soup mixes from Dry-Pack vegetables, is in operation at Sodus.

In Tennessee and Georgia, the Tennessee Valley Authority in cooperation with university and state departments of agriculture conducted experimental work on the development and adaptation of equipment and techniques for dehydrating southern grown fruits and vegetables.* There have already developed successful community dehydration plants and smaller home dehydrators, built of inexpensive wood. State agency pilot plants are located in Knoxville, Clarkesville, and Experiment, Georgia. Demonstration plants in vocational schools are at Forsyth, Vienna, and Sparta, Georgia.

At the Phoenix Indian school, Dr. W.A. Beavens of Los Angeles has built an experimental dehydrator.** For some years in the one hundred Indian boarding schools, canning has been carried on in a small way with the students doing the work. In 1942, because of the metal shortage, they turned to dehydration. Up until that time, they had been exchanging canned goods. They now will exchange dehydrated foods, but on a more extensive scale. If the pilot plant at Phoenix proves to be successful, dehydrators will be set up in most or all of

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*Christian Science Monitor-Food Dehydration Speeded-March 1[illegible],1943.

**Christian Science Monitor-Dehydration May be Undertaken on Large Scale at Indian Schools- October 10, 1942.

the schools; the Phoenix dehydrated carrots, oranges, and grapefruit will be exchanged for dehydrated Washington apples, Idaho potatoes, and California spinach. At Phoenix so far "the results are pronounced delicious."*

At North Girard, Pennsylvania, the Northwestern Potato Cooperative was organized to dehydrate white potatoes. The association experienced the usual difficulties of an organization introducing a new product. Production problems arising from the necessity of inventing and building a portion of its equipment also have required much time and effort on the part of the manag-ment.** Their product is a cooked, riced potato to be served after adding hot water and heating for seven minutes, then whipping and seasoning to taste. The association has a single conveyor drier, supertype, designed for the automatic handling and drying of vegetables.

The Rio Grande By Products Corporation in McAllen, Texas was formed in 1940 with financial aid from the Farm Security Administration to manufacture pectin from citrus pulp, a waste cannery product.** The plant is equipped with two types of driers; namely, the drum type for dehydrating pectin, and the rotary cylinder type for dehydrating the citrus pulp which is stored and later used in making pectin. To extend the operating season

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*Christian Science Monitor-Dehydration May be Undertaken on Large Scale at Indian Schools - October 10, 1942.
**Hensley,W.C.--"Dehydration of Fruits and Vegetables",1946 U.S. Farm Credit Administration.

for pectin beyond the months which citrus pulp is available directly from the canneries. The company installed steam-tube rotary driers to dehydrate the pulp and store it in air cooled steel tanks; this drier is not adapted to the dehydration of vegetables. Natural gas is used for fuel.

Cooperatives have long been the leaders in the production of dried fruits. They market one quarter of a total annual production of more than a billion pounds, with a value of more than fifty million dollars. The trend has been in recent years toward dehydration, although many of these fruits are still termed "dried." Many cooperative canneries, in addition, have entered this field or are operating pilot plants to familiarize themselves with this type of processing.

In the dominion of Canada, at present, five out of the eight plants capable of dehydrating vegetables are under government supervision. The five plants are distributed one in British Columbia, processing carrots; two in Ontario, processing cabbage and potatoes; and two in Nova Scotia, processing potatoes and turnips. These plants act as pilot plants, using the tentative methods developed in the laboratories of the Experimental Farms service.

The type of dehydration used is a hot-end-loading two-way-air-flow tunnel which was developed by C.C. Zidt

of the Dominion Experimental Station, Kentville, Nova Scotia.* This type of dehydrator is capable of drying ten tons of cabbage; fifty tons of potatoes, turnips, or carrots; or sixty tons of apples in a twenty-four hour period. Air is forced through the tunnel by two fans, one at either end, with a capacity of 40,000 cubic feet per minute and 20,000cubic feet per minute respectively. Heat is supplied by steam radiators and the temperature within the tunnel is automatically controlled. Dampers are installed in all the ducts so that the air flow and relative humidity are under absolute control at all times.

The prepared product is placed on trays placed on trucks which move through two tunnels. In the first tunnel they pass from a high temperature to a lower temperature; in the secondary tunnel the trucks move from a low temperature to a higher temperature. This two way method of drying insures even drying on all parts of the trays.

Preprocessing, or blanching, is an absolute must if a desirable product is to be obtained of suitable edibility, nutritive value, and keeping quality. There still seems to be considerable controversy as to the advisability of preprocessing of vegetables for drying.

*Aitken, H.C.-"How Canada Dehydrates Foods"-May 1945 Food Industries

In Canada, however, there is the conviction that it is a necessity. The destruction of enzyme activity is prerequisite for the retention of quality.

At present, in Canada, five gallon tins are used with press-in lids and solder-on caps to package the dehydrated vegetables. Constant experimentation has shown that an inert atmosphere has greater keeping qualities. Therefore the air in the tins is replaced by nitrogen or carbon dioxide. This method has not as yet been perfected but is proving satisfactory for present day use.

"To produce a dehydrated product that upon reconstitution is attractive, edible, and at the same time retains its maximum nutritive value, is the object of all dehydration research and production in Canada today."*

*Aitken, H.C.-"How Canada Dehydrates Foods"-May, 1948 Food Industries.

Dehydrated Egg Industry

The dehydrated egg industry is an excellent example of the many individual dehydrating industries which are now in the production of dehydrated products. These producers realize the necessity of expert knowledge to produce a finished product of lasting quality. At their meeting at Kansas City, Missouri in September of 1941 they paved the way for the expansion of the industry to meet the new wartime needs. By exchanging the results of past experience and experimentation, a serious effort was made to place the scale of production on a scientific basis.

The art of drying eggs is one of the oldest processes of food technology in existence. In the United States egg drying was started in the middle west about thirty-eight years ago. The cheaper shell eggs of China soon put an end to the industry here because of the lack of a protective tariff. This effected the mass migration of both plants and equipment to China. Soon China was supplying the world with dried egg products.*

In July of 1931, the eighteen cent tariff then in force on the dried egg products was raised to twenty-seven cents per pound. Importation dropped from the 1930 figure of 10,000,000 pounds to 3,000,000 pounds in 1932. Imports gradually increased again until in 1937 8,871,000 pounds of dried egg products came into this country from

*Sulvetta, H.A.-"How Eggs are Dried"-December, 1941. Food Industries.

China. The Japanese invasion of China and lower prices at home cut importations down again to 1,[illegible],000 pounds in 1939.*

By 1938 the low domestic prices for eggs and the lack of imports from the Orient stimulated the dehydration of eggs again in the United States. Much of the dehydrated egg products used in this country is for commercial use. The albumen in particular is used in making candy and meringues.

The pre-war domestic consumption was 15,000,000 pounds including imports. On January first of 1942, the dehydrating plants operating 360 days on a twenty-two to twenty-four hour basis produced 150,000,000 pounds. The potential peacetime production of a four month season on an eight hour day will be 17,000,000 pounds. Two million pounds will then be available for new domestic uses and consumption as well as for exportation.*

At the Dried Egg School held in Kansas City, Missouri in September of 1941, W.F. Leimert of the Tranin Egg Products Company broke approximate costs down into factors of raw materials, including storage, breaking labor, drying, amortization of plant, and administration.

*Mulvany, M.A.-"How Eggs Are Dried", December , 1941 Food Industries.

1. Assuming an average yearly cost of thirty cents per dozen of eggs and a yield of ten pounds of dried whole eggs per thirty dozen case, the raw material cost becomes eighty-eight cents per pound of dried eggs. If eggs are to be stored for drying during winter, or out of the heavy laying period, a storage cost of ten cents per case per month, or one cent per pound of powder, should be taken into consideration.

2. Breaking costs, including labor and supplies, were given as 1¼ cents per pound of powder.

3. Drying costs, including power, fuel and packaging materials, totaled four cents per pound of powder.

4. Amortization of plant cost, set up on a one year basis because of twenty-four hour per day operation, was calculated to be two cents per pound of powder.

5. Administration expense of two cents per pound of powder brought manufacturing costs to a total of thirteen cents per pound; added to the raw materials cost of eighty-eight cents, the total cost for powder becomes $1.01, figured on a year round shell cost of thirty cents per dozen. Warning was given that the prices being paid by the government at present should not be taken as a continued price for the calculation of a possible profit.*

*Stateler, E.S.-"School Paves Way for Spectacular Expansion of Dried-Egg Industry."--Food Industries, November, 1941.

D.A. Weeks of Armour and Company in an effort to clarify the problems of production presented the following pointers at the same time:

1. Good wholesome eggs, the first requirement.

2. Plant must be maintained in good sanitary condition.

3. Close supervision must be maintained over breaking operations.

4. Selection of equipment used influences yields obtained.

5. Follow through for maintenance of quality of finished product essential to retention of peacetime market.*

Of particular importance is the maintenance of a properly equipped and capably staffed control laboratory to operate as many hours a day as the plant is in production. The perishability of the liquid egg between the point of breaking and the point of drying must be considered and held to a minimum. Positive control of the moisture content of the finished product is essential to its stability during shipping and storage whether under refrigeration or at normal room temperatures. These are but a few of the points which are the concern of the control laboratory.

*Stateler, E.S.-"School Paves Way for Spectacular Expansion of Dried-Egg Industry"--Food Industries, November, 1941.

The meeting at Kansas City laid the groundwork for the potential healthy growth of the egg dehydrating industry into a state of maturity. The crux of the problem depends on how seriously the new comers into the industry heed the standards set up. The already established concerns must integrate their collective knowledge and experience.

The standards of quality of the dehydrated egg industry may well apply to any other dehydrating industry. The problems of production are the same with proper adjustment for each respective product.

Conclusions

The dehydration industry has two paths to follow in the near future and post-war era; it may become a formidable competitor to or an adjunct of the frozen foods and canning industries.

As an independent industry there are many examples of small plants which have cropped up almost overnight in response to the increased demand of our armed forces and lend-lease aid. In Maine where there was only one allied industry, there are now eight dehydrating plants. Farmers' Cooperatives are in the field. Canada has eight government supervised plants dehydrating vegetables. Just as the Civil War acted as the sponsor of the canning industry; so the first World War and the present one are sponsoring this aspect of food technology as a national industry.

As an adjunct of the frozen foods and canning industries, the dehydrating industry has the greater advantage of established brand names and business experience. The steps leading up to the final stage of canning, freezing, or dehydrating are identical; the source of power for dehydrating purposes can be easily supplied by the canneries - in fact some of the present dehydrating plants are entirely dependent upon the boilers of adjacent canneries for their heat supply. All three types of plants must be located in great vegetable producing areas for best results; the shipping and trans-

portation problems are the same; the sales and distribution outlets are the same. Due to wartime restrictions and the lack of essential raw materials some of the minor canning factories have already converted part of their plants to the process of dehydration. The major industries, Campbell, Heinz, and Beech-nut, have already made plans for the immediate conversion of parts of their respective plants upon demand (winter 1942-43).

Ninety percent of the present production of dehydrated foods is destined for our armed forces and lend-lease aid. The remaining ten percent is dispersed over the civilian consumer market. Families on relief through the blue stamp plan were introduced to dehydrated products in an effort to conserve our surplus commodities. At present this plan is defunct because there are no surplus commodities. A good percentage of our civilian market is now being introduced to dehydrated products due to the rationing of canned soups and vegetables. There are at present about fifty different brands of dehydrated soups on the market.

Until two or three years ago not much work had been done to improve the processes of dehydration. The pressure of wartime production has accomplished in one year what would ordinarily have taken ten years. The improvement in processes and the increase of interest is now one hundred fold over that of the past decade. There

is still great possibility for improvement and laboratories all over the country are engaged in the development of these processes. By the end of this war, the dehydration industry should reach the peak of development at which the canning industries are now. There are no definite figures of our present capacity for dehydration because of the rapid addition of new plants.

The War Production Board in July of 1943 declared that an allocation of vital materials would be made to add to the existing facilities. At that time we had an annual capacity of about

milk..... 84,[illegible],000 pounds

eggs.....110,[illegible],000

fruits and vegetables.....66,[illegible],000

meat.....60,000,000

Secretary Wickard expects production for the 1943-[illegible] season to reach the estimated demands of

milk.....515,000,000 pounds

eggs.....300,000,000

fruits and vegetables.....400,000,000

meat.....180,000,000

The widespread expansion necessary to meet these market requirements will leave a full grown industry after the present emergency has passed. The independent companies will not of their own free will close down. Even the canning concerns which have introduced

dehydrating as strictly a wartime measure and can easily scrap all equipment at a profit will not liquidate their assets if there seems to be a possibility that the consumer market will accept dehydrated products as they already have accepted canned goods and frozen foods.

Until the present stimulating interest became necessary, the American public had not realized the extent to which they had depended upon canned goods. Although, at present, the probability for consumer acceptance of dehydrated products is small; cleverly planned advertising campaigns and extensive consumer education can make dehydrated products a staple part of the consumer diet.

Dehydrated foods in themselves have certain advantages. When properly prepared and packaged they can withstand heat and cold much more readily and even better than fresher canned foods. Great in flavor, aroma, and nutritive value are preserved. They are already cut, named, dried, often already cooked. The only additions necessary are water and/or seasoning in most cases. There are limitations to the recipes, of course; but dehydrated foods are not recommended as a steady diet nor would they be accepted as such. There is place for fresh, canned, frozen, and dehydrated foods.

Eye-appeal is of prime importance in the sales appeal of any product. The bulk of the packaged dehy-

dried products is of an insignificant degree. On the one hand they are small and save space; but on the other hand it is difficult to sell a package which although small will be able to compete with the other larger goods on the grocer's shelf. The advertising ability and salesmanship of our American industrial concerns will produce the attractive packages necessary.

Through advertising campaigns such as are now appearing in the newspapers, magazines, on the radio; "dehydrated" and "dried" will come to be household words. Store demonstrations, cooking schools, and lecturers will provide the necessary consumer education; these would be particularly pertinent in the first stage of preparation, "refreshing." The proper amount of water must be added to attain correct and thorough reconstitution of the product. Directions on the package must be explicit. Unless these are followed carefully, an unsatisfactory product will result.

Dehydrated foods have a different and characteristic taste, which will have to be introduced to the American palate. The foods are palatable but the taste is different. "Pure," "The Flavor that Refreshes," and "It's Toasted" need no explanation. Why not a slogan such as IT'S DELICIOUS for dehydrated products. Consumer propaganda has won out before, this should not be an exception. Once the idea is implanted in the minds

of the consumers in addition to the actual advantages of dehydrated foods, the taste for these foods can be cultivated.

This does not mean that the dehydrated foods cannot get by on their own merit; for, when properly prepared and packaged, they retain more vitamins and nutritional value than the canned and frozen products. However, our consumer public has depended too long on advertising campaigns for its knowledge of goods. When a little known product is mentioned, regardless of its high quality, the answer is "Never heard of it." The radio, newspapers, magazines (Good Housekeeping), and lecturers dictate what shall be on pantry shelves, bathrooms, garages, and homes. The advertising campaigns, however, should not attempt to make dehydrated foods the main part of the diet--for, as a steady source of food, they are not practical. A family would soon tire of three meals a day of dehydrated foods.

The cost of production of these foods at present is slightly below that for canning. Production on a higher scale with greater coordination in production methods will bring these costs to an even lower figure. Greater value is shipped at the same transportation cost for an equal bulk of canned goods. The present discrimination in shipping rates against dehydrated

products will be adjusted as the industry grows.*

Scientific preparation, packaging, and storage give dehydrated products superior keeping quality in all types of climate and altitudes. Their concentration will permit the higher cost of transportation by plane to otherwise inaccessible territories.

In conclusion, the future of the dehydrating industry depends fundamentally on their acceptance by consumers. Expert knowledge is necessary to produce a product of high quality. The slip-shod methods of the last war produced an inferior product. History may repeat itself as the war progresses, but American industrialists have learned to profit by their past experience. The results of past, present, and future laboratory findings are the foundation on which standards of quality are to be based. "If insistence is laid upon the high quality of the raw material and the use only of the best methods, the dehydrating industry in the United States will develop at a rapid rate and become a powerful factor in the conservation movement and in the stabilization of agricultural crops."** The possibilities of the dehydrating industry are evident.

**Prescott, S.C.--"Commercial Dehydration"--, 1919 and Sweet, L.D.

*Lockley, Lawrence C.--"Dehydrated Foods" --Harvard Business Review --Winter Number 1943.

The added merits and advantages of the products themselves in cooperation with vigorous advertising campaigns and merchandising will bring about the stabilization of dehydrating as a thriving and established industry.

Abstract

Dehydrated foods are now coming into prominence as rivals of canned and frozen products. In my opinion, the conclusion of the present world conflict will find dehydrating an established industry with a future in the post-war markets. The drying of food has been a well known method of food technology for hundreds of years. Archeologists have found stores of dried grains in excavations. The Indians taught the early New England colonists to dry corn, apples, peas, and other vegetables. The dried cod was a staple commodity and a source of wealth to the Massachusetts Bay colony in trade.

The introduction of canning about one hundred years ago completely overshadowed the simpler process of drying. However, the advent of the Civil War, the Spanish-American War, and especially the last world war brought about renewed interest in dehydrating as an emergency measure. During recent years knowledge about dehydrating has increased greatly. The best products are practically equal to the fresh ones in flavor, texture, and nutritive value. Under the sponsorship of the Government Dehydrating Committee the present methods are undergoing revolutionary changes in processing and packaging. The government hopes that a permanent industry will be established which will extend to and be of great value to all our people. This close cooperation between the government and the dehydrating industry is indicative of the closer alliance between

industry and government which will result from the present conflict.

Dehydrated foods in themselves have certain advantages. These are the lower cost of actual units, space saving, guaranteed keeping quality under varied conditions, labor saving, a wider range for diet. Greater flavor, aroma, and the nutritive values of the foods are fully conserved. The greatest economic factor in the use of dehydrating methods is the utilization of food stuffs which would ordinarily go to waste due to low prices at the time of production or difficulties in transportation or marketing. From the standpoint of agriculture the greatest advantage is in the stabilization of crops and the conservation of materials.

The disadvantages connected with the use of dehydrated foods are the entirely distinctive flavor, the period of soaking for reconstitution, careful adherence to directions, and the losses due to improper packaging.

Research on the processes of dehydrating has indicated the necessity for inactivating the enzymes of vegetables and fruits by scalding or other means before dehydrating in order to obtain palatibility, high vitamin content, and good keeping qualities. When carefully processed, dehydrated foods surpass canned and frozen products in nutritive value.

Dehydration is not a field to be entered in a haphazard manner by anyone. The quality of the dehydrated products made available at present will determine the post-war position of the industry. Many inconveniences will be tolerated during the emergency only. Only certain varieties and grades of fruits and vegetables have been found to be suitable for dehydration. Expert handling and knowledge of the dehydrating process is essential for a product of good quality.

There are five principal types of dehydrators -- the cabinet, tunnel, drum, spray, and rotary unit dehydrators. Their names are self explanatory. Each type has its special uses and no single type is best for all purposes. The sources of heat may be indirect or direct. The indirect is through a steam boiler, the direct through a gas- or oil-fired burner.

It is customary to store the dried fruits and vegetables in bins or "sweat boxes" to permit equalization of the moisture before packaging. Even after packaging the dehydrated products are often stored before shipment. In storage, insect damage presents a serious hazard. Regular and thorough fumigation of the storage rooms is necessary to assure a finished product of good keeping quality.

The quality of the finished product as it reaches the final consumer is dependent, also, upon the materials

used in packaging as fully as it is upon the quality of the raw materials used in preparing the product. The package should act as a barrier between the dehydrated product and the outside moisture, light, insect life.

Since vegetables and fruits for dehydrating should be processed fresh, it is desirable to locate the plant near or even in an important vegetable or fruit producing section. A dependable source of labor should be readily available with access to adequate transportation facilities.

The production of dehydrated foods is carried on at present in improvement dehydrating plants, partially converted canning factories, in conjunction with canning, in schools, cooperatives, and in pilot plants.--- the Dry-Pack-Corporation, the Phoenix Indian School, the North-western Potato Cooperative, the Ocean Spray Company. Outstanding pioneers in the dehydrating industry are the large dehydrating companies. These companies have cooperated fully with government bureaus in all phases and have held many joint meetings to exchange the results of past experience and experimentation. They have placed production on a strictly scientific basis which is ideal for a product of good quality to meet the strictest post-war requirements.

In conclusion, the future of the dehydrating industry depends fundamentally on acceptance of the products by consumers. "If acceptance is left upon the high quality

of the raw material and the use only of the best methods, the dehydrating industry in the United States will develop at a rapid rate and become a powerful factor in the conservation movement and in the stabilization of agricultural crops."* The added merits and advantages of the products themselves in cooperation with vigorous advertising campaigns and merchandising will bring about the stabilization of dehydrating as a thriving and established industry.

*Prescott, S.C. and Sweet, L.D. -- "Commercial Dehydration", 1919.

Appendix

Established Brands in Production of Dehydrated Foods

Lipton's Continental Soups.

General Mill's Betty Crocker Soups.

Skinner and Eddy Corporation's Minute Man Soups.

Mrs. Grass' Soups.

Appella Crisps--dehydrated apples and apple powder.

Appella Corporation, Selah, Washington.

Weep No More My Ladies -- onion flakes.

Little and Company, Chicago, Ill.

Thyler and Company, Chicago, Ill.

Chopped Parsley.

Onion Flakes.

Klim -- dehydrated skimmed milk.

Ocean Spray --dehydrated cranberries and cranberry sauce.

Poultrymen's Cooperative Association of the State of Washington -- dehydrated eggs in New York City.

Industrias Franco do Amaral of Brazil.

Dehydrated banana flakes.

Definition of "dehydrated"

The National Dehydration Control Committee considers a product "dehydrated" when as a result of controlled artificial drying, the moisture content of any particle of the finished product does not exceed 10% by weight (1942)

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